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DECLARATION

I, Koichi OISHI Patent Attorney, of OISHI & PARTNERS, 8th Floor, Yusen-Awajicho Building, 1-4-1, Kandaawajicho, Chiyoda-ku, Tokyo 101-0063 Japan, hereby certify that I am the translator of the certified official copy of the documents in respect of an application for a Patent filed in Japan on July 1, 2002 under Patent Application No. 2002-191613 and that the following is a true and correct translation to the best of my knowledge and belief.

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[TITLE OF THE INVENTION]

OPTICAL RECORDING MEDIUM AND OPTICAL RECORDING METHOD

[CLAIMS]

[Claim 1] An optical recording medium comprising a substrate, a recording layer formed over the substrate and a dielectric layer formed adjacent with the recording layer, the optical recording medium being constituted so that when it is irradiated with a laser beam for recording data and a recording mark is formed at a predetermined region of the recording layer, the state of at least a part of a region of the dielectric layer corresponding to the region of the recording layer where the recording mark is formed changes.

[Claim 2] An optical recording medium in accordance with Claim 1, wherein the at least a part of the region of the dielectric layer corresponding to the region of the recording layer where the recording mark is formed is crystallized to form a crystallized region.

[Claim 3] An optical recording medium in accordance with Claim 1 or 2, wherein the recording layer comprises at least a first reaction layer and a second reaction layer and an element contained in the first reaction layer and an element contained in the second reaction layer are mixed with each other when the recording layer is irradiated with the laser beam, thereby forming the recording mark.

[Claim 4] An optical recording medium in accordance with Claim 3,

wherein the first reaction layer contains an element selected from a group consisting of Cu, Al, Zn and Ag as a primary component and the second reaction layer contains an element selected from a group consisting of Si, Ge and Sn.

[Claim 5] An optical recording medium in accordance with Claim 4, wherein the first reaction layer contains an additive(s).

[Claim 6] An optical recording medium in accordance with any one of Claims 1 to 5, wherein the dielectric layer comprises a first dielectric layer and a second dielectric layer formed so as to sandwich the recording layer therebetween.

[Claim 7] An optical recording medium in accordance with any one of Claims 1 to 6, which further comprises a light transmission layer disposed opposite to the substrate as viewed from the recording layer and wherein the light transmission layer has a thickness of 10 μm to 300 μm.

[Claim 8] An optical recording method for recording data in an optical recording medium comprising a substrate, a recording layer formed over the substrate and a dielectric layer formed adjacent with the recording layer, the optical recording method comprising steps of projecting a laser beam onto the recording layer, thereby forming a recording mark at a predetermined region of the recording layer and changing the state of at least a part of a region of the dielectric layer corresponding to the region of the recording layer where the recording mark is formed.

[Claim 9] An optical recording method in accordance with Claim 8, wherein the at least a part of the region of the dielectric layer corresponding to the region of the recording layer where the recording mark is formed is crystallized to form a crystallized region.

[Claim 10] An optical recording method in accordance with Claim 8 or 9, wherein a pulse train pattern for modulating the power of the laser beam is set to a single pulse pattern having a pulse width corresponding to a length of a recording mark to be formed.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[FIELD OF THE INVENTION]

The present invention relates to an optical recording medium and a method for optically recording information in the optical recording medium and, particularly, to an optical recording medium whose recording layer includes a plurality of reaction layers and an optical recording method for optically recording data in the optical recording medium having such a structure.

[0002]

[DESCRIPTION OF THE PRIOR ART]

Optical recording media such as the CD, DVD and the like have been widely used as recording media for recording digital data. These optical recording media can be roughly classified into optical recording media such as the CD-ROM and the DVD-ROM that do not enable writing and rewriting of data (ROM type optical recording media), optical recording media such as the CD-R and DVD-R that enable writing but not rewriting of data (write-once type optical recording media), and

optical recording media such as the CD-RW and DVD-RW that enable rewriting of data (data rewritable type optical recording media).

[0003]

As well known in the art, data are generally recorded in a ROM type optical recording medium using prepits formed in a substrate in the manufacturing process thereof, while in a data rewritable type optical recording medium a phase change material is generally used as the material of the recording layer and data are recorded utilizing changes in an optical characteristic caused by phase change of the phase change material.

[0004]

On the other hand, in a write-once type optical recording medium, an organic dye such as a cyanine dye, phthalocyanine dye or azo dye is generally used as the material of the recording layer and data are recorded utilizing changes in an optical characteristic caused by chemical change of the organic dye, which change may be accompanied by physical deformation.

[0005]

However, since an organic dye is degraded when exposed to sunlight or the like, it is difficult to improve long-time storage reliability in the case where an organic dye is used as the material of the recording layer. Therefore, it is desirable for improving long-time storage reliability of the write-once type optical recording medium to form the recording layer of a material other than an organic dye. As disclosed in Japanese Patent Application Laid Open No. 62-204442, an optical recording material formed by laminating two reaction layers is known as an example of an optical recording medium whose recording layer is formed of a material other than an organic dye. In the optical recording medium

disclosed in Japanese Patent Application Laid Open No. 62-204442, the recording layer is constituted by two reaction layers laminated onto each other when no data are recorded therein. When data are to recorded in the optical recording medium, a laser beam is projected onto a predetermined region of the recording layer to mix materials contained in the two reactions layers to each other, thereby forming eutectic. As a result, since the optical properties are difference between regions of the recording layer constituted by two reactions layers laminated onto each other and the region where the eutectic is formed, data can be recorded in the recording layer utilizing the difference in the optical properties.

[0006]

[PROBLEMS TO BE SOLVED BY THE INVENTION]

However, since the difference between the optical properties of the region where the eutectic is formed of the materials contained in the two reaction layers and those of other regions is not so large, it is difficult to record data in the optical recording medium only by mixing the materials contained in the two reaction layers to form the eutectic of the materials contained in the two recording layers. In particular, a next-generation type optical recording medium that offers improved recording density and has an extremely high data transfer rate has been recently proposed. In such a next-generation type optical recording medium, since it is necessary to reduce the diameter of the laser beam spot used to record and reproduce data to a very small size, the difference between the optical properties of the region where the eutectic is formed of the materials contained in the two reaction layers and those of other regions is required to be sufficiently large. Therefore, it is extremely difficult to reproduce a signal having a good signal characteristic only by mixing the materials contained in the two reaction layers to form the eutectic of the

materials contained in the two recording layers.

[0007]

This problem is particularly serious in an optical recording medium including a recording layer constituted by a plurality of reaction layers but the same problem occurs in optical recording media other than the optical recording medium including a recording layer constituted by a plurality of reaction layers.

[0008]

It is therefore an object of the present invention to provide an optical recording medium which can increase the difference in optical properties thereof between before and data are recorded therein and those after data are recorded therein.

[0009]

Another object of the present invention is to provide an optical recording method for recording data in an optical recording medium and capable of increasing the difference in optical properties of the optical recording medium between before data are recorded in the optical recording medium and after data are recorded therein.

[0010]

[MEANS FOR SOLVING THE PROBLEMS]

The inventors of the present invention pursued a study in order to increase the difference in optical properties of the optical recording medium between before data are recorded in an optical recording medium and after data are recorded therein and, as a result, made the discovery that when the optical recording medium was irradiated with a laser beam to change the state of a recording layer, if the state of at least a part of a dielectric layer adjacent with the recording layer was changed, the difference in the optical properties between before data were recorded

in the optical recording medium and after data were recorded therein could be increased and the signal characteristics such as a C/N ratio and jitter of a reproduced signal could be improved.

[0011]

The present invention is based on these technical findings and the above object of the present invention can be accomplished by an optical recording medium comprising a substrate, a recording layer formed over the substrate and a dielectric layer formed adjacent with the recording layer, the optical recording medium being constituted so that when it is irradiated with a laser beam for recording data and a recording mark is formed at a predetermined region of the recording layer, the state of at least a part of a region of the dielectric layer corresponding to the region of the recording layer where the recording mark is formed changes.

[0012]

According to the present invention, since the state of at least a part of a region of the dielectric layer corresponding to the region of the recording layer where the recording mark is formed changes in addition to the change of the state of the recording layer, it is possible to considerably increase the difference in optical properties of the optical recording medium between before data are recorded in the optical recording medium and after data are recorded therein as a whole, whereby the signal characteristics such as a C/N ratio and jitter of a reproduced signal could be improved. Therefore, even in the case where it is particularly required to increase the difference in optical properties of the optical recording medium between before data are recorded in the optical recording medium and after data are recorded therein like a next-generation type optical recording medium, a reproduced signal having a good signal characteristic can be obtained.

[0013]

Furthermore, in the present invention, it is preferable for the at least a part of the region of the dielectric layer corresponding to the region of the recording layer where the recording mark is formed to be crystallized to form a crystallized region. In such a case, a well known crystallizable material such as $ZnS \cdot SiO_2$ can be employed as a material for forming a dielectric layer.

[0014]

Further, in the present invention, preferably, the recording layer comprises at least a first reaction layer and a second reaction layer and an element contained in the first reaction layer and an element contained in the second reaction layer are mixed with each other when the recording layer is irradiated with the laser beam, thereby forming the recording mark. In the case where the recording layer is constituted in this manner, it is possible to increase the strength of a reproduced signal.

[0015]

In this case, it is preferable for the first reaction layer to contain an element selected from a group consisting of Cu, Al, Zn and Ag as a primary component and for the second reaction layer to contain an element selected from a group consisting of Si, Ge and Sn. In the case where the first reaction layer contains an element selected from a group consisting of Cu, Al, Zn and Ag as a primary component and the second reaction layer contains an element selected from a group consisting of Si, Ge and Sn, it is possible to further lower the noise level of a reproduced signal and reduce a load applied onto an environment.

[0016]

Moreover, in the present invention, the first reaction layer

contains an additive(s). In the case where the first reaction layer contains an additive(s), it is possible to further lower the noise level of a reproduced signal and improve a long term storage reliability of an optical recording medium. Further, since the thermal conductivity of the first reaction layer is lowered by addition of the additive(s), it is possible to facilitate the change of the state of the dielectric layer.

[0017]

Furthermore, in the present invention, it is preferable for the dielectric layer to comprise a first dielectric layer and a second dielectric layer formed so as to sandwich the recording layer therebetween. In the case where the dielectric layer comprises a first dielectric layer and a second dielectric layer formed so as to sandwich the recording layer therebetween, it is possible to effectively protect the recording layer.

[0018]

Moreover, in the present invention, it is preferable for an optical recording medium to further comprise a light transmission layer disposed opposite to the substrate as viewed from the recording layer and for the light transmission layer to have a thickness of 10 µm to 300 µm. In a next-generation type optical recording medium having such a thin light transmission layer, although the difference in optical properties of the optical recording medium between before data are recorded in the optical recording medium and after data are recorded therein is required to be particularly large, according to the present invention, it is possible to obtain a reproduced signal having a good signal characteristic even in the next-generation type optical recording medium.

[0019]

An optical recording method according to the present invention comprises steps of projecting a laser beam onto the recording layer,

thereby forming a recording mark at a predetermined region of the recording layer and changing the state of at least a part of a region of the dielectric layer corresponding to the region of the recording layer where the recording mark is formed.

[0020]

According to the present invention, since the state of at least a part of a region of the dielectric layer corresponding to the region of the recording layer where the recording mark is formed changes in addition to the change of the state of the recording layer, as described above, it is possible to considerably increase the difference in optical properties of the optical recording medium between before data are recorded in the optical recording medium and after data are recorded therein as a whole.

[0021]

Further, in the present invention, it is preferable for the at least a part of the region of the dielectric layer corresponding to the region of the recording layer where the recording mark is formed to be crystallized to form a crystallized region. In such a case, a well known crystallizable material such as $ZnS \cdot SiO_2$ can be employed as a material for forming a dielectric layer.

[0022]

Furthermore, in the present invention, it is preferable to set a pulse train pattern for modulating the power of the laser beam to a single pulse pattern having a pulse width corresponding to a length of a recording mark to be formed. In the case where a pulse train pattern for modulating the power of the laser beam is set to a single pulse pattern having a pulse width corresponding to a length of a recording mark to be formed, since a sufficient amount of heat can be applied to the recording layer, it is possible to effectively change the state of the dielectric layer.

[0023]

[DESCRIPTION OF THE PREFERRED EMBODIMENTS]

Hereinafter, a preferred embodiment of the present invention will now be explained with reference to accompanying drawings.

[0024]

Figure 1 is a schematic cross-sectional view showing the structure of an optical recording medium that is a preferred embodiment of the present invention.

[0025]

As shown in Figure 1, an optical recording medium 10 according to this embodiment is constituted as a write-once type optical recording medium and includes a substrate 11, a reflective layer 12 formed on the surface of the substrate 11, a second dielectric layer 13 formed on the surface of the reflective layer 12, a recording layer 14 formed on the surface of the second dielectric layer 13, a first dielectric layer 15 formed on the surface of the recording layer 14 and a light transmission layer 16 formed on the surface of the first dielectric layer 15. A hole 17 is formed at a center portion of the optical recording medium 10. In this embodiment, data are recorded in and reproduced from the optical recording medium 10 having such a structure by projecting a laser beam from the side of the light transmission layer 16.

[0026]

The substrate 11 serves as a support for ensuring mechanical strength required for the optical recording medium 10 and grooves 11a and lands 11b are alternately formed on the surface of the substrate 11. The grooves 11a and/or lands 11b serve as a guide track for the laser beam L10 when data are to be recorded or when data are to be reproduced. In this embodiment, the substrate 11 has a thickness of

about 1.1 mm. The material used to form the substrate 11 is not particularly limited and substrate 11 can be formed of glass, ceramic, resin or the like, for example. Among these, resin is preferably used for forming the substrate 11 since resin can be easily shaped. Illustrative examples of resins suitable for forming the substrate 40 include polycarbonate resin, acrylic resin, epoxy resin, polystyrene resin, polyethylene resin, polypropylene resin, silicone resin, fluoropolymers, acrylonitrile butadiene styrene resin, urethane resin and the like. Among these, polycarbonate resin is most preferably used for forming the substrate 11 from the viewpoint of easy processing and the like. Since the substrate 11 constitutes a surface of the optical recording medium 10 opposite to the light incidence plane, it is unnecessary for the substrate 11 to have a light transmission ability.

[0027]

The reflective layer 12 serves to reflect the laser beam L10 entering through the light transmission layer 16 so as to emit it from the light transmission layer 16. The thickness of the reflective layer 12 is not particularly limited but is preferably from 5 nm to 300 nm, more preferably from 20 nm to 200 nm. The material used to form the reflective layer 12 is not particularly limited insofar as it can reflect a laser beam, and the reflective layer 12 can be formed of Mg, Al, Ti, Cr, Fe, Co, Ni, Cu, Zn, Ge, Ag, Pt, Au and the like. Among these materials, it is preferable to form the reflective layer 12 of a metal material having a high reflection characteristic, such as Al, Au, Ag, Cu or alloy containing at least one of these metals, such as alloy of Al and Ti. In the present invention, it is not absolutely necessary to provide the reflective layer 12 in the optical recording medium but in the case where the reflective layer 12 is provided in the optical recording medium, it is possible to

easily obtain a high reproduced signal (C/N ratio) by a multiple interference effect.

[0028]

The first dielectric layer 15 and the second dielectric layer 13 serve to protect the recording layer 14 formed therebetween . Degradation of data optically recorded in the recording layer 14 can be prevented over a long period by the first dielectric layer 13 and the second dielectric layer 15. Further, since the first dielectric layer 13 also serves to prevent the substrate 11 and the like from being deformed by heat, it is possible to effectively prevent jitter and the like from becoming worse due to the deformation of the substrate 11 and the like.

[0029]

The first dielectric layer 15 and/or the second dielectric layer 13 also serve as an auxiliary recording layer and when the state of the recording layer 14 changes by the irradiation with the laser beam, the state of the first dielectric layer 15 and/or the second dielectric layer 13 simultaneously changes, whereby the difference in the total optical properties (reflective coefficient) of the optical recording medium between before data are recorded in the optical recoding medium and after data are recorded therein increases. In this embodiment, the statement that the state of the first dielectric layer 15 and/or the second dielectric layer 13 changes means that materials for forming the first dielectric layer 15 and/or the second dielectric layer 13 is crystallized to form a crystallized region.

[0030]

The material used to form the first dielectric layer 15 and the second dielectric layer 13 is not particularly limited insofar as it is a transparent dielectric material and it contains a crystallizable material.

The first dielectric layer 15 and the second dielectric layer 13 can be formed of a dielectric material containing oxide, sulfide, nitride or a combination thereof, for example, as a primary component. More specifically, in order to prevent the substrate 11 and the like from being deformed by heat and thus protect the first recording layer 31 and the second recording layer 32, it is preferable for the first dielectric layer 15 and the second dielectric layer 13 to contain at least one kind of dielectric material selected from the group consisting of Al_2O_3, AlN, ZnO, ZnS, GeN, GeCrN, CeO, SiO, SiO_2, SiN and SiC as a primary component and it is more preferable for the first dielectric layer 15 and the second dielectric layer 13 to contain $ZnS \cdot SiO_2$ as a primary component. The first dielectric layer 15 and the second dielectric layer 13 may be formed of the same dielectric material or of different dielectric materials. Moreover, at least one of the first dielectric layer 15 and the second dielectric layer 13 may have a multi-layered structure including a plurality of dielectric films.

[0031]

Here, the statement that the first dielectric layer 15 or the second dielectric layer 13 contains a certain dielectric material means that the content of the dielectric material is maximum among components contained in the first dielectric layer 15 or the second dielectric layer 13 and $ZnS \cdot SiO_2$ means a mixture of ZnS and SiO_2.

[0032]

The thickness of the first dielectric layer 15 and the second dielectric layer 13 is not particularly limited but is preferably from 3 nm to 200 nm. If the first dielectric layer 15 or the second dielectric layer 13 is thinner than 3 nm, it is difficult to obtain the above-described advantages. On the other hand, if the first dielectric layer 15 or the

second dielectric layer 13 is thicker than 200 nm, it takes a long time to form the first dielectric layers 15 and the second dielectric layers 13, thereby lowering the productivity of the optical recording medium 10, and cracks may be generated in the optical recording medium 10 owing to stress present in the first dielectric layers 15 and/or the second dielectric layer 13.

[0033]

The recording layer 14 is a layer in which a recording mark is to be formed and includes a reaction layer 31 and a reaction layer 32 adjacent with the reaction layer 31. The reaction layer 32 is disposed on the side of the substrate 11 and the reaction layer 31 is disposed on the side of the light transmission layer 16. As shown in Figure 3 (a), the reaction layer 31 and the reaction layer 32 are laminated at an unrecorded region of the recording layer 14. When the recording layer 14 is irradiated with a laser beam having a predetermined power or more, the element contained in the reaction layer 31 as a primary component and the element contained in the reaction layer 32 as a primary component partially or totally diffuse by heat generated by the laser beam to mix with each other, whereby a recording mark is formed, as shown in Figure 3 (b). As a result, since the reflection coefficient of a mixed region of the recording layer where the recording mark is formed and that of other regions of the recording layer with respect to a laser bream for reproducing data are greatly different from each other, data can be recorded in and reproduced from the optical recording medium 10 utilizing the difference in the reflection coefficient between the region where the recording mark is formed and other regions.

[0034]

Further, when a recording mark M is formed in the recording

layer 14 by the irradiation with the laser beam, the material contained in a part or whole of a region of the first dielectric layers 15 and/or the second dielectric layer 13 corresponding to the recording mark M is crystallized by heat generated by the irradiation with the laser beam, thereby forming a crystallized region M' as shown Figure 2 (b). Although Figure 2 (b) shows a case where the crystallized region M' is formed at a whole region of a region of the first dielectric layers 15 and the second dielectric layer 13 corresponding to the recording mark M, it is sufficient for the crystallized region M' to be formed in one of the first dielectric layers 15 or the second dielectric layer 13 and it is sufficient for the crystallized region M' to be formed at at least a part of a region of the first dielectric layers 15 or the second dielectric layer 13 corresponding to the recording mark M. Since the reflection coefficient of the thus formed crystallized region M' is different from those of the first dielectric layers 15 and the second dielectric layer 13 corresponding to regions where no recording mark M is formed, the total difference between the reflection coefficient of a region where a recording mark M is formed and that of regions where no recording mark M is formed becomes larger than that when the state of the first dielectric layers 15 and/or the second dielectric layer 13 does not change. Thus, it is possible to improve a signal characteristic such as a C/N ratio and jitter of a reproduced signal in comparison with the case where the state of the first dielectric layers 15 and/or the second dielectric layer 13 does not change.

[0035]

In this embodiment, it is preferable for the reaction layer 31 to contain an element selected from the group consisting of Al, Si, Ge, C, Sn, Au, Zn, Cu, B, Mg, Ti, Mn, Fe, Ga, Zr, Ag, Bi and Pt as a primary component and for the reaction layer 32 to contain as a primary

component an element selected from the group consisting of Al, Si, Ge, C, Sn, Au, Zn, Cu, B, Mg, Ti, Mn, Fe, Ga, Zr, Ag, Bi and Pt and different from the element contained in the reaction layer 31 as a primary component. In particular, in order to suppress the noise level of a reproduced signal, it is more preferable for one of the reaction layer 31 and the reaction layer 32 to contain an element selected from the group consisting of Cu, Al, Zn and Ag as a primary component and for the other of the reaction layer 31 and the reaction layer 32 to contain an element selected from the group consisting of Si, Ge and Sn as a primary component and it is most preferable for one of the reaction layer 31 and the reaction layer 32 to contain Cu as a primary component and for the other of the reaction layer 31 and the reaction layer 32 to contain Si as a primary component. In the case where each of the reaction layer 31 and the reaction layer 32 contain the above identified elements as a primary component, it is possible suppress the noise level of a reproduced signal and simultaneously reduce a load applied onto the environment.

[0036]

Further, in the case where one of the reaction layer 31 and the reaction layer 32 contains Cu as a primary component, it is preferable to add an element selected from the group consisting of Al, Zn, Sn, Au and Mg to the reaction layer and in the case where one of the reaction layer 31 and the reaction layer 32 contains Al as a primary component, it is preferable to add an element selected from the group consisting of Mg, Au, Ti and Cu to the reaction layer. Furthermore, in the case where one of the reaction layer 31 and the reaction layer 32 contains Zn as a primary component, it is preferable to add an element selected from the group consisting of Mg, Al and Cu to the reaction layer and in the case where one of the reaction layer 31 and the reaction layer 32 contains Ag

as a primary component, it is preferable to add an element selected from the group consisting of Cu and Pd to the reaction layer. In the case where the above identified element is added to the reaction layer, it is possible to further lower the noise level of a reproduced signal and improve a long term storage reliability of the optical recording medium 10. Moreover, in the case where the above identified element is added to the reaction layer, since the thermal conductivity of the reaction layer can be lowered, it is possible to increase an amount of heat applied to the first dielectric layer 15 and the second dielectric layer 13 when the recording layer 14 is irradiated with the laser beam, thereby effectively facilitating the crystallization of the element contained in the first dielectric layer 15 or the second dielectric layer 13. Here, in this specification, "a primary component" means an element whose content (atomic %) is maximum among elements contained in the layer.

[0037]

As the thickness of the recording layer 14 becomes thicker, the surface smoothness of the surface 31a of the reaction layer 31 irradiated with the beam spot of the laser beam becomes worse so that the noise level of a reproduced signal increases and the recording sensitivity of the recording layer 14 becomes lower. Considering these, it is effective to set the thickness of the recording layer 14 thinner in order to improve the surface smoothness of the surface 31a of the reaction layer 31 so that the noise level of a reproduced signal can be suppressed, the recording sensitivity of the recording layer 14 can be improved and the element contained in the first dielectric layer 15 or the second dielectric layer 13 can be effectively crystallized but in the case where the thickness of the recording layer 14 is set too thin, the change in the optical characteristics between before and after the recording of data, so that a reproduced

signal having high strength (C/N ratio) cannot be obtained. Further, in the case where the thickness of the recording layer 14 is set too thin, it becomes difficult to control the thickness of the recording layer 14. Considering these, it is preferable to set the thickness of the recording layer 14 to 2 nm to 40 nm, it is more preferable to set the thickness thereof to 2 nm to 20 nm and it is particularly preferable to set the thickness thereof to 2 nm to 15 nm.

[0038]

The individual thicknesses of the reaction layer 31 and the reaction layer 32 are not particularly limited but in order to considerably suppress the noise level of a reproduced signal, considerably improve the recording sensitivity and greatly increase the change in reflection coefficient between before and after the recording of data, the thickness of each of the reaction layer 31 and the reaction layer 32 is preferably from 1 nm to 30 nm. Further, it is preferable to define the ratio of the thickness of the reaction layer 31 to the reaction layer 32 (thickness of reaction layer 31 / thickness of the reaction layer 32) to be from 0.2 to 5.0.

[0039]

The light transmission layer 16 constitutes a light incidence plane of the laser beam and serves to transmit a laser beam. The light transmission layer 16 preferably has a thickness of 10 μm to 300 μm. More preferably, the light transmission layer 16 has a thickness of 50 μm to 150 μm. The material used to form the light transmission layer 16 is not particularly limited but an ultraviolet ray curable resin is preferably used for forming the light transmission layer 16. Instead of forming the light transmission layer of an ultraviolet ray curable resin, the light transmission layer 16 may be formed using a sheet made of light transmittable resin, various adhesive agents and agglutinants.

[0040]

The optical recording medium 10 having the above-described configuration can, for example, be fabricated in the following manner.

[0041]

The substrate 11 formed with the grooves 11a and the lands 11b is first formed using a stamper. Then, the reflective layer 12 is formed on the surface of the substrate 11 formed with the grooves 11a and the lands 11b. The reflective layer 12 can be formed by a gas phase growth process using chemical species containing elements for forming the reflective layer 12. Illustrative examples of the gas phase growth processes include vacuum deposition process, sputtering process and the like.

[0042]

Next, the second dielectric layer 13 is formed on the surface of the reflective layer 12. The second dielectric layer 13 can be also formed by a gas phase growth process using chemical species containing elements for forming the second dielectric layer 13. The reaction layer 32 constituting the recording layer 14 is then formed on the second dielectric layer 13. The reaction layer 32 can be also formed by a gas phase growth process using chemical species containing elements for forming the reaction layer 32 in the similar manner to that for forming the second dielectric layer 13. The reaction layer 31 is further formed on the reaction layer 32. The reaction layer 31 can be also formed by a gas phase growth process using chemical species containing elements for forming the reaction layer 31. The first dielectric layer 15 is then formed on the reaction layer 31. The first dielectric layer 15 can be also formed by a gas phase growth process using chemical species containing elements for forming the first dielectric layer 15.

[0043]

Finally, the light transmission layer 16 is formed on the first dielectric layer 15. The light transmission layer 16 can be formed by applying acrylic ultraviolet curing resin or epoxy ultraviolet curing resin whose viscosities are adjusted onto the first dielectric layer 15 to form a coating layer, projecting an ultraviolet ray onto the coating layer and curing the acrylic ultraviolet curing resin or the epoxy ultraviolet curing resin. Thus, the optical recording medium 10 was fabricated.

[0044]

Here, a method for fabricating an optical recording medium is not limited to the above described method and a known technique for fabricating an optical recording medium can be used for fabricating the optical recording medium 1 of the present invention.

[0045]

Next, an optical recording method using the optical recording medium 10 having the above described structure will be explained below.

[0046]

First, the principle of recording information in the optical recording medium 10 will be explained.

[0047]

In the case where information is to be recorded in the optical recording medium 10, as shown in Figure 1, the laser beam L10 having a predetermined power is projected onto the recording layer 14 via the light transmission layer 16. At this time, it is preferable to use an objective lens having a numerical aperture of 0.7 or larger for converging the laser beam L10 and it is particularly preferable to use an objective lens having a numerical aperture of about 0.85. Further, it is preferable to use a laser beam L10 having a wavelength λ of 450 nm or shorter and it is particularly preferable to use a laser beam L10 having a wavelength

λ of about 405 nm. Thus, it is preferable to set λ/NA to be equal to or smaller than 640 nm.

[0048]

When the laser beam L10 having the above identified wavelength is projected onto the recording layer 14, the element contained in the reaction layer 31 as a primary component and the element contained in the reaction layer 32 as a primary component are heated by the laser beam L10 and are mixed to each other. As shown in Figure 2 (b), the thus formed mixed region of element contained in the reaction layer 31 as a primary component and the element contained in the reaction layer 32 as a primary component serves as a recording mark M. Further, when the recording mark M is formed, the material contained in the first dielectric layer 15 and/or the second dielectric layer 13 is crystallized, thereby forming a crystallized region M'. Since the reflection coefficient of the mixed region of the recording layer 14 where the recording mark M becomes different from those of other regions of the recording layer 14 and the reflection coefficient of the crystallized region M' becomes different from those of other regions of the first dielectric layer 15 and/or the second dielectric layer 13, the total reflection coefficient of the region where the recording mark M is formed and the crystallized region M' is greatly different from other regions. Therefore, it is possible to record data in and reproduce data from the optical recording medium 10 utilizing the difference between the reflection coefficients of the region where the recording mark M is formed and the crystallized region M' is greatly different and the reflection coefficient of other regions.

[0049]

The above is the principle of recording information in the optical recording medium 10. Hereinafter, a concrete pulse train pattern used in

this embodiment will be explained below. Here, a "pulse train pattern" means an optimum method for modulating the power of a laser beam to be projected onto an optical recording medium for forming a recording mark M and is also referred to as a "write strategy".

[0050]

In the optical recording method according to this embodiment, a pulse train pattern capable of forming a recording mark M in the recording layer 14 and forming a crystallized region M' in the first dielectric layer 15 and/or the second dielectric layer 13 is used. Here, in order to form a crystallized region M' in the first dielectric layer 15 and/or the second dielectric layer 13, it is necessary to apply a sufficient amount of heat to the first dielectric layer 15 and/or the second dielectric layer 13. However, the amount of heat applied to the first dielectric layer 15 and the second dielectric layer 13 is greatly influenced by the thermal conductivity of the recording layer 14 and a linear recording velocity. More specifically, in the case where the thermal conductivity of the recording layer 14 is high, in other words, in the case where the thermal conductivities of the elements constituting the recording layer are high and where the linear recording velocity is high, the amount of heat applied to the first dielectric layer 15 and the second dielectric layer 13 becomes small. On the other hand, in the case where the thermal conductivity of the recording layer 14 is low, in other words, in the case where the thermal conductivities of the elements constituting the recording layer are low and where the linear recording velocity is low, the amount of heat applied to the first dielectric layer 15 and the second dielectric layer 13 becomes large. Therefore, it is necessary to consider the thermal conductivity of the recording layer 14 and the linear recording velocity in order to determine what pulse train pattern is used.

[0051]

Thus, in this embodiment, in the case where the thermal conductivity of the recording layer 14 is high and where the linear recording velocity is high, a single pulse train pattern described in detail later is employed, while in the case where the thermal conductivity of the recording layer 14 is low and where the linear recording velocity is low, a basic pulse train pattern described in detail later is employed.

[0052]

Figure 3 is a diagram showing the waveform of a single pulse pattern for the case where 2T signal to 8T signal are recorded in the (1, 7) RLL modulation mode.

[0053]

As shown in Figure 3, in the single pulse pattern, the single pulse has a width corresponding to the length of a record mark M to be formed and the laser beam is set to have a recording power (***Pw1***) at the peak thereof and to have a ground power (***Pb1***) at other times.

[0054]

The recording power (***Pw1***) is set to a high level at which the element contained in the reaction layer 31 as a primary component and the element contained in the reaction layer 32 as a primary component can be heated and mixed and the material contained in the first dielectric layer 15 and/or the second dielectric layer 13 is crystallized when a laser beam having the recording power (***Pw1***) is projected onto the optical recording medium 10. On the other hand, the ground power (***Pb1***) is set to a low level at which the element contained in the reaction layer 31 as a primary component and the element contained in the reaction layer 32 as a primary component cannot be substantially mixed and the material contained in the first dielectric layer 15 and/or the second dielectric layer

13 is not substantially crystallized when a laser beam having the ground power (*Pb1*) is projected onto the optical recording medium 10.

[0055]

Although the ground power (*Pb1*) may be set to the same level as the reproducing power (*Pr*), it is preferable to set the ground power (*Pb1*) to be higher than the reproducing power (*Pr*), as shown in Figure 3. In the case where the ground power (*Pb1*) is set higher than the reproducing power (*Pr*) in this manner, the temperature of the track can be raised as a whole by the laser beam having the ground power (*Pb1*) and the heating of the optical recording medium 10 by the recording power (*Pw1*) can be assisted by the ground power (*Pb1*). It is therefore possible to form a record mark M and crystallized regions M' without setting the level of the recording power (*Pw1*) so high.

[0056]

Therefore, even in the case where the thermal conductivity of the recording layer 14 is high and the recording linear velocity is high, it is possible to mix the element contained in the reaction layer 31 as a primary component and the element contained in the reaction layer 32 as a primary component, thereby forming a record mark M and to form crystallized regions M' at regions of the first dielectric layer 15 and the second dielectric layer 13 adjacent to the record mark M. Thus, the difference between the total reflection coefficient of the region where the recording mark M is formed and those of the unrecorded regions can be increased.

[0057]

Figure 4 is a diagram showing the waveform of a basic pulse train pattern wherein Figure 4 (a) shows a pulse train pattern for recording a 2T signal in the (1, 7) RLL modulation mode and Figure 4 (b) shows a

pulse train pattern for recording 3T signal to 8T signal.

[0058]

As shown in Figure 4 (a) and Figure 4 (b), in the basic pulse train pattern, the pulse for forming a record mark M and the crystallized region M' is divided into (n-1) pulses and the laser beam is set to have a recording power (***Pw2***) at the peak of each of the divided pulses and to have a ground power (***Pb2***) at other times. Thus, since it is possible to prevent the total amount of heat applied to the recording layer 14 from becoming excessive, it is possible to prevent the width of a recording mark M from becoming large and cross-talk of data from increasing.

[0059]

The recording power (***Pw2***) is set to a high level at which the element contained in the reaction layer 31 as a primary component and the element contained in the reaction layer 32 as a primary component can be heated and mixed and the material contained in the first dielectric layer 15 and/or the second dielectric layer 13 is crystallized when a laser beam having the recording power (***Pw2***) is projected onto the optical recording medium 10. On the other hand, the ground power (***Pb2***) is set to a low level at which the element contained in the reaction layer 31 as a primary component and the element contained in the reaction layer 32 as a primary component cannot be substantially mixed and the material contained in the first dielectric layer 15 and/or the second dielectric layer 13 is not substantially crystallized when a laser beam having the ground power (***Pb2***) is projected onto the optical recording medium 10.

[0060]

Although the ground power (***Pb2***) may be set to the same level as the reproducing power (***Pr***), it is preferable to set the ground power (***Pb2***) to be higher than the reproducing power (***Pr***), as shown in Figure 4 (a)

and Figure 4 (b) insofar as the width of a recording mark M can be prevented from becoming large. In the case where the ground power (***Pb2***) is set to be higher than the reproducing power (***Pr***), since the heating of the optical recording medium 10 by the recording power (***Pw2***) can be assisted by the ground power (***Pb2***) in this manner, it is possible to form a record mark M and crystallized regions M' without setting the level of the recording power (***Pw2***) so high.

[0061]

Thus, since it is possible to mix the element contained in the reaction layer 31 as a primary component and the element contained in the reaction layer 32 as a primary component, thereby forming a record mark M and to form crystallized regions M' at regions of the first dielectric layer 15 and the second dielectric layer 13 adjacent to the record mark M, the difference between the total reflection coefficient of the region where the recording mark M is formed and those of the unrecorded regions can be increased.

[0062]

These are concrete pulse train patterns according to this embodiment.

[0063]

It is preferable to store information for identifying the above described pulse train patterns according to this embodiment in the optical recording medium 10 as "information for setting recording conditions". In the case where such information for setting recording conditions is stored in the optical recording medium 10, when data are to be recorded in the optical recording medium 10 by the user, since the information for setting recording conditions is read by an information recording apparatus, the pulse train pattern can be determined based on

the thus read information for setting recording conditions.

[0064]

It is preferable for the information for setting recording conditions to include not only information for identifying a pulse train pattern but also information necessary for identifying various conditions necessary for recording data in the optical recording medium 10 such as a linear recording velocity. The information for setting recording conditions may be recorded in the form of wobbles or pits or may be recorded in the recording layer 14 as data. The information for setting recording conditions is not limited to information directly indicating respective conditions necessary for recording data but may be information which can indirectly identify recording conditions by specifying one of the conditions stored in the information recording apparatus in advance based thereon.

[0065]

Figure 5 is a diagram for schematically showing a primary portion of an information recording apparatus for recording data in the optical recording medium 10.

[0066]

As shown in Figure 5, the information recording apparatus includes a spindle motor 52 for rotating the optical recording medium 10, a head 53 for projecting a laser beam L10 onto the optical recording medium 10 and receiving light reflected from the optical recording medium 10, a controller 54 for controlling the operations of the spindle motor 52 and the head 53, a laser drive circuit 55 for feeding a laser drive signal and a lens drive circuit 56 for feeding a lens drive signal to the head 53.

[0067]

As shown in Figure 5, the controller 54 includes a focus servo circuit 57, a tracking servo circuit 58 and a laser control circuit 59. When the focus servo circuit 57 is activated, a laser beam L10 is focused on the first recording layer 31 of the optical recording medium 10 being rotated and when the tracking servo circuit 58 is activated, the spot of the laser beam L10 automatically follows a track of the optical recording medium 10. The focus servo circuit 57 and the tracking servo circuit 58 have automatic gain control capability for automatically regulating focus gain and automatic gain control capability for automatically regulating tracking gain, respectively. The laser control circuit 59 generates the laser drive signal fed to the head 53 by the laser drive circuit 55 and generates a proper laser drive signal based on the information for setting recording conditions.

[0068]

Note that the focusing servo circuit 57, tracking servo circuit 58 and laser control circuit 59 need not be circuits incorporated in the controller 54 but can instead be components separate of the controller 54. Moreover, they need not be physical circuits but can instead be accomplished by software programs executed in the controller 54.

[0069]

When data are to recorded in the optical recording medium 10 according to this embodiment using the thus constituted information recording apparatus 50, the information for setting recording conditions recorded on the optical recording medium 10 is read and the pulse train pattern is determined based on the thus read information for setting recording conditions.

[0070]

As described above, in this embodiment, when data are to be

recorded in the optical recording medium 10, since the material contained in the region of the first dielectric layer 15 and the second dielectric layer 13 corresponding to the region of the recording layer 14 where a recording mark M is formed is crystallized, it is possible to increase the difference between the optical properties of the region of the recording layer 14 where a recording mark M is formed and those of other regions (blank regions). Therefore, even in the case where a recording layer of a next-generation type optical recording medium is constituted by a plurality of reaction layers, it is possible to improve the signal characteristics such as a C/N ratio and jitter of a signal obtained by reproducing a recorded signal.

[0071]

The present invention has thus been shown and described with reference to a specific embodiment. However, it should be noted that the present invention is in no way limited to the details of the described arrangements but changes and modifications may be made without departing from the scope of the appended claims.

[0072]

For example, in the optical recording medium 10 according to the above described embodiment, although the recording layer 14 is held between the first dielectric layer 15 and the second dielectric layer 13, one of the first dielectric layer 15 and the second dielectric layer 13 may be omitted.

[0073]

Further, in the optical recording medium 10 according to the above described embodiment, although the recording layer 14 is constituted by the two reaction layers laminated on each other, an optical recording medium of the present invention is not limited to that having

such configuration and an optical recording medium may include a recording layer constituted by three or more layers insofar as the recording layer includes at least one reaction layer and at least one reaction layer adjacent to the first mentioned reaction layer. For example, an optical recording medium may include a recording layer having a three layer configuration including two reaction layers 31 and one second reaction layer disposed between these two reaction layers. Further, a mixed layer formed by mixing the material contained in the reaction layer 31 and the material contained in the reaction layer 32 may be disposed between the reaction layer 31 and the reaction layer 32.

[0074]

Moreover, in the optical recording medium 10 according to the above described embodiment, although the reflective layer 12 is formed on the substrate 11, in the case where the difference in the levels between light reflected from the region where a recording mark M is formed and unrecorded regions is considerable large, the reflective layer 12 may be omitted.

[0075]

Furthermore, in the above described embodiment, although the explanation was made as to the next-generation type optical recording medium having an extremely thin light transmission layer 16, the present invention is not limited to application to such an optical recording medium. However, since it is more difficult to obtain a large output signal in the next-generation type optical recording medium than in the conventional optical recording medium, it is particularly effective for the present invention to be applied to the next-generation type optical recording medium.

[0076]

[WORKING EXAMPLES]

Hereinafter, working examples will be set out in order to further describe the present invention concretely. However, the present invention is in no way limited to the working examples.

[0077]

[Preparation of Optical Recording Medium Sample]

(Sample 1)

An optical recording medium sample 1 having the same configuration as that of the optical recording medium 10 shown in Figure 1 was fabricated in the following manner.

[0078]

More specifically, a polycarbonate substrate 11 having a thickness of 1.1 mm and a diameter of 120 mm was first set on a sputtering apparatus. Then, a reflective layer 12 containing Ag as a primary component and having a thickness of 100 nm, a second dielectric layer 13 containing a mixture of ZnS and SiO_2 and having a thickness of 28 nm, a reaction layer 32 containing Cu as a primary component and 21 atomic % of Mg as an additive and having a thickness of 5 nm, a reaction layer 31 containing Si as a primary component and having a thickness of 5 nm and a first dielectric layer 15 containing the mixture of ZnS and SiO_2 and having a thickness of 22 nm were sequentially formed on the polycarbonate substrate using the sputtering process.

[0079]

Further, the first dielectric layer 15 was coated using the spin coating method with an acrylic ultraviolet curing resin to form a coating layer and the coating layer was irradiated with ultraviolet rays, thereby curing the acrylic ultraviolet curing resin to form a light transmission layer 16 having a thickness of 100 μm.

[0080]

The mole ratio of ZnS to SiO_2 in the mixture of ZnS and SiO_2 contained in the first dielectric layer 15 and the second dielectric layer 13 was 80:20.

[0081]

(Sample 2)

An optical recording medium sample 2 was fabricated in the manner of the sample 1, except that a reaction layer 32 containing Cu as the primary component and 17 atomic % of Al as an additive was formed.

[0082]

(Sample 3)

An optical recording medium sample 3 was fabricated in the manner of the sample 1, except that a reaction layer 32 containing Al as the primary component and 17 atomic % of Mg as an additive was formed.

[0083]

(Sample 4)

An optical recording medium sample 4 was fabricated in the manner of the sample 1, except that a reaction layer 32 containing only Cu was formed.

[0084]

(Sample 5)

An optical recording medium sample 5 was fabricated in the manner of the sample 1, except that a reaction layer 32 containing only Ag was formed.

[0085]

(Sample 6)

An optical recording medium sample 6 was fabricated in the

manner of the sample 1, except that a reaction layer 32 containing Cu as the primary component and 23 atomic % of Al and 12.8 atomic % of Au as additives was formed.

[0086]

[Optical Characteristics Comparison Test 1]

In the Optical Characteristics Comparison Test 1, data were recorded in each of the samples 1, 2 and 4 in which the reaction layer 32 contained Cu as a primary component, the signal characteristics of a reproduced signal were measured and the state of the recording layer 14 and the states of the first dielectric layer 15 and the second dielectric layer 13 after recording data were observed.

[0087]

More specifically, each of the thus fabricated optical recording medium samples 1, 2 and 4 was set in an optical recording medium evaluation apparatus "DDU1000" (Product Name) manufactured by Pulstec Industrial Co., Ltd. Then, a laser beam having a blue light wavelength (405 nm) and an objective lens having a numerical aperture of 0.85 were employed and the laser beam was converged onto each of the optical recording medium samples 1, 2 , 4 using a condenser lens from the side of the light transmission layer 16, thereby optically recording data therein. As a recording signal, a 2T signal in (1.7) RLL Modulation Code was used and the basic pulse train pattern shown in Figure 4 was used. Further, the pulse width was set to 0.5 T and the ground power (***Pb2***) and the recording power (***Pw2***) were set to 0.1 mW and 5.0 mW, respectively. Moreover, the linear recording velocity was set to 5.3 m/sec and the channel clock was set to 66 MHz. In this case, a data transfer rate taking the format efficiency to be 80% was about 35 Mbps.

[0088]

Then, the thus recorded signal was reproduced and a C/N ratio and jitter of a reproduced signal ware measured. Here, jitter means clock jitter and when clock jitter was measured, the fluctuation σ of a reproduced signal was measured using a time interval analyzer and the clock jitter was calculated as σ/Tw, where Tw was one clock period. The results of the measurement are shown in Table 1.

[0089]

Table 1

	C/N ratio (dB)	jitter(%)
Sample 1	58.7	8.5
Sample 2	58.3	8.8
Sample 3	56.6	9.5

As shown in Table 1, it was found that the C/N ratio and jitter were better in the optical recording medium samples 1 and 2 than those in the optical recording medium sample 4.

[0090]

Then, in each of the optical recording medium samples 1, 2 and 4, the state of a region of the recording layer 14 where a recording mark M was formed, the states of regions of the first dielectric layer 15 and the second recording layer 13 corresponding to the region of the recording layer 14 where the recording mark M was formed, the state of a blank region of the recording layer 14 and the states of regions of the first dielectric layer 15 and the second recording layer 13 corresponding to the blank region of the recording layer 14 were observed. When the state of the recording layer 14 was observed using Auger analyzing method and the states of the first dielectric layer 15 and the second recording layer 13 were observed using a TEM (transmission type electron microscope).

[0091]

As a result, it was confirmed in each of the optical recording medium samples 1, 2 and 4 that the element contained in the reaction layer 31 as a primary component and the element contained the reaction layer 32 as a primary component were mixed at the region of the recording layer 14 where the recording mark M was formed and that the reaction layer 31 and the reaction layer 32 were layered at the blank region of the recording layer 14 where no recording mark M was formed. Therefore, it was found that there was no difference in the state of the recording layer 14 between the optical recording medium samples 1, 2 and 4.

[0092]

On the other hand, ZnS crystal was observed at regions of the first dielectric layer 15 and the second dielectric layer 13 adjacent to the region of the recording layer 14 where the recording mark M was formed in each of the optical recording medium samples 1 and 2 but such a crystal was not observed at regions of the first dielectric layer 15 and the second dielectric layer 13 adjacent to the region of the recording layer 14 where the recording mark M was formed in the optical recording medium sample 4.

[0093]

Thus, it was confirmed that the difference between the signal characteristics of the reproduced signals obtained from the optical recording medium samples 1 and 2 and those of the reproduced signals obtained from the optical recording medium sample 4 was derived from the states of the first dielectric layer 15 and the second dielectric layer 13. It can be considered that this is because Mg or Al was added to the reaction layer 32 containing Cu as a primary component in each of the

optical recording medium samples 1 and 2 and therefore, the thermal conductivity of the recording layer 14 in each of the optical recording medium samples 1 and 2 was lower than that in the optical recording medium sample 4 in which the reaction layer 32 contained only Cu, whereby the temperatures of the first dielectric layer 15 and the second dielectric layer 13 was higher in each of the optical recording medium samples 1 and 2 than those in the optical recording medium sample 4.

[0094]

[Optical Characteristics Comparison Test 2]

In the Optical Characteristics Comparison Test 2, data were recorded in each of the samples 3 and 5 in which the reaction layer 32 contained Al as a primary component and the state of the recording layer 14 and the states of the first dielectric layer 15 and the second dielectric layer 13 after recording data were observed. Data were recorded and the state of the recording layer 14 and the states of the first dielectric layer 15 and the second dielectric layer 13 were observed in the manner of the Optical Characteristics Comparison Test 1.

[0095]

As a result, it was confirmed in each of the optical recording medium samples 3 and 5 that the element contained in the reaction layer 31 as a primary component and the element contained the reaction layer 32 as a primary component were mixed at the region of the recording layer 14 where the recording mark M was formed and that the reaction layer 31 and the reaction layer 32 were layered at the blank region of the recording layer 14 where no recording mark M was formed. On the other hand, ZnS crystal was observed at regions of the first dielectric layer 15 and the second dielectric layer 13 adjacent to the region of the recording layer 14 where the recording mark M was formed in the optical recording

medium sample 3 but such a crystal was not observed at regions of the first dielectric layer 15 and the second dielectric layer 13 adjacent to the region of the recording layer 14 where the recording mark M was formed in the optical recording medium sample 5.

[0096]

Thus, it was also confirmed in the case where the reaction layer 32 contained Al as a primary component, similarly to the case where the reaction layer 32 contained Cu as a primary component that the material contained in the first dielectric layer 15 and/or the second dielectric layer 13 could be crystallized by adding an additive to the reaction layer 32 and lowering the thermal conductivity of the recording layer 14.

[0097]

[Optical Characteristics Comparison Test 3]

In the Optical Characteristics Comparison Test 3, data were recorded in the optical recording medium sample 6 using the pulse train patter shown in Figure 3 (the single pulse pattern) and the pulse train pattern shown in Figure 4 (the basic pulse train pattern), the signal characteristics of a reproduced signal were measured and the state of the recording layer 14 and the states of the first dielectric layer 15 and the second dielectric layer 13 after recording data were observed.

[0098]

In the case where data were recorded using the single pulse pattern, the ground power (***Pb1***) and the recording power (***Pw1***) were set to 0.1 mW and 3.8 mW, respectively. On the other hand, in the case where data were recorded using the basic pulse train pattern, the pulse width was set to 0.3 T and the ground power (***Pb2***) and the recording power (***Pw2***) were set to 0.1 mW and 5.0 mW, respectively. In both cases, the linear recording velocity was set to 5.3 m/sec and the channel clock

was set to 66 MHz. In this case, a data transfer rate taking the format efficiency to be 80% was about 35 Mbps.

[0099]

Then, the thus recorded signal was reproduced and a C/N ratio and jitter of a reproduced signal ware measured. The results of the measurement are shown in Table 2.

[0100]

Table 2

	C/N (dB)	jitter (%)
Single Pulse Pattern	62.7	8.0
Basic Pulse Train Pattern	61.8	8.7

As shown in Table 2, it was found that the C/N ratio and jitter were better when the single pulse pattern was used than those when the basic pulse train pattern was used.

[0101]

In both cases where the basic pulse train pattern was used and where the single pulse pattern was used, it was confirmed that the element contained in the reaction layer 31 as a primary component and the element contained the reaction layer 32 as a primary component were mixed at the region of the recording layer 14 where the recording mark M was formed and that the reaction layer 31 and the reaction layer 32 were layered at the blank region of the recording layer 14 where no recording mark M was formed. Therefore, it was found that there was no difference in the state of the recording layer 14 between the case where

the basic pulse train pattern was used and the case where the single pulse pattern was used.

[0102]

On the other hand, as a result of observing the states of the first dielectric layer 15 and the second dielectric layer 13, ZnS crystal was observed at regions of the first dielectric layer 15 and the second dielectric layer 13 adjacent to the region of the recording layer 14 where the recording mark M was formed in the case where the single pulse pattern was used but such a crystal was not observed in the case where the basic pulse train pattern was used.

[0103]

Thus, it was confirmed that the difference between the signal characteristics of the reproduced signals shown in Table 2 was derived from the states of the first dielectric layer 15 and the second dielectric layer 13. It can be considered that this is because the total amount of heat applied to the first dielectric layer 15 and the second dielectric layer 13 was larger when the single pulse pattern was used than that when the basic pulse train pattern was used and the temperatures of the first dielectric layer 15 and the second dielectric layer 13 was higher when the single pulse pattern was used than that when the basic pulse train pattern was used.

[0104]

As described above, in the present invention, since not only the state of the recording layer but also the states of the dielectric layer provided adjacent to the recording layer are changed when data are recorded, the change between the optical properties before data are recorded in the optical recording medium and those after data are recorded therein can be increased. Therefore, even in the case where a

recording layer of the next-generation type optical recording medium is constituted by a plurality of reaction layers, the signal characteristics such as a C/N ratio and jitter of a signal obtained by reproducing recorded signal can be improved.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[Figure 1]

Figure 1 is a schematic cross-sectional view showing the structure of an optical recording medium that is a preferred embodiment of the present invention.

[Figure 2]

Figure 2 (a) is an enlarged cross sectional view schematically showing a region of an optical recording medium where no data are recorded and Figure 2 (b) is an enlarged cross sectional view schematically showing a region of an optical recording medium where a recording mark M is formed.

[Figure 3]

Figure 3 is a diagram showing the waveform of a single pulse pattern.

[Figure 4]

Figure 4 is a diagram showing the waveform of a basic pulse train pattern wherein Figure 4 (a) shows a pulse train pattern for recording a 2T signal in the (1, 7) RLL modulation mode and Figure 4 (b) shows a pulse train pattern for recording 3T signal to 8T signal.

[BRIEF DESCRIPTION OF REFERENCE NUMERALS]

10 ..... an optical recording medium

11 ..... a substrate

11a ..... a land

11b ..... a groove

12 ..... a reflective layer

13 ..... a second dielectric layer

14 ..... a recording layer

15 ..... a first dielectric layer

16 ..... a light transmission layer

17 ..... a hole

31, 32 ..... a reaction layer

31b ..... a surface of a reaction layer

50 ..... an information recording apparatus

52 ..... a spindle motor

53 ..... a head

54 ..... a controller

55 ..... a laser drive circuit

56 ..... a lens drive circuit

57 ..... a focus servo circuit

58 ..... a tracking servo circuit

59 ..... a laser control circuit

L10 ..... a laser beam

M ..... a recording mark

M' ..... a crystallized region

FIG. 1

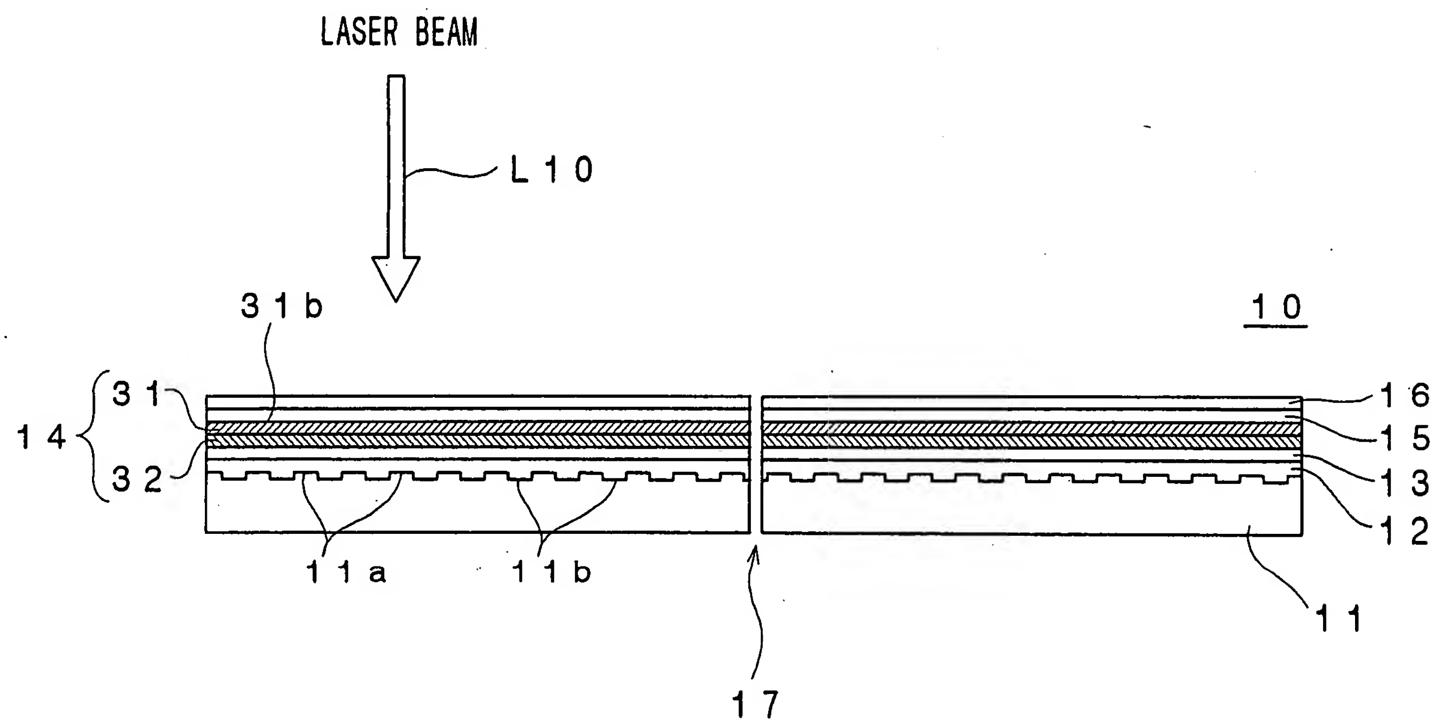
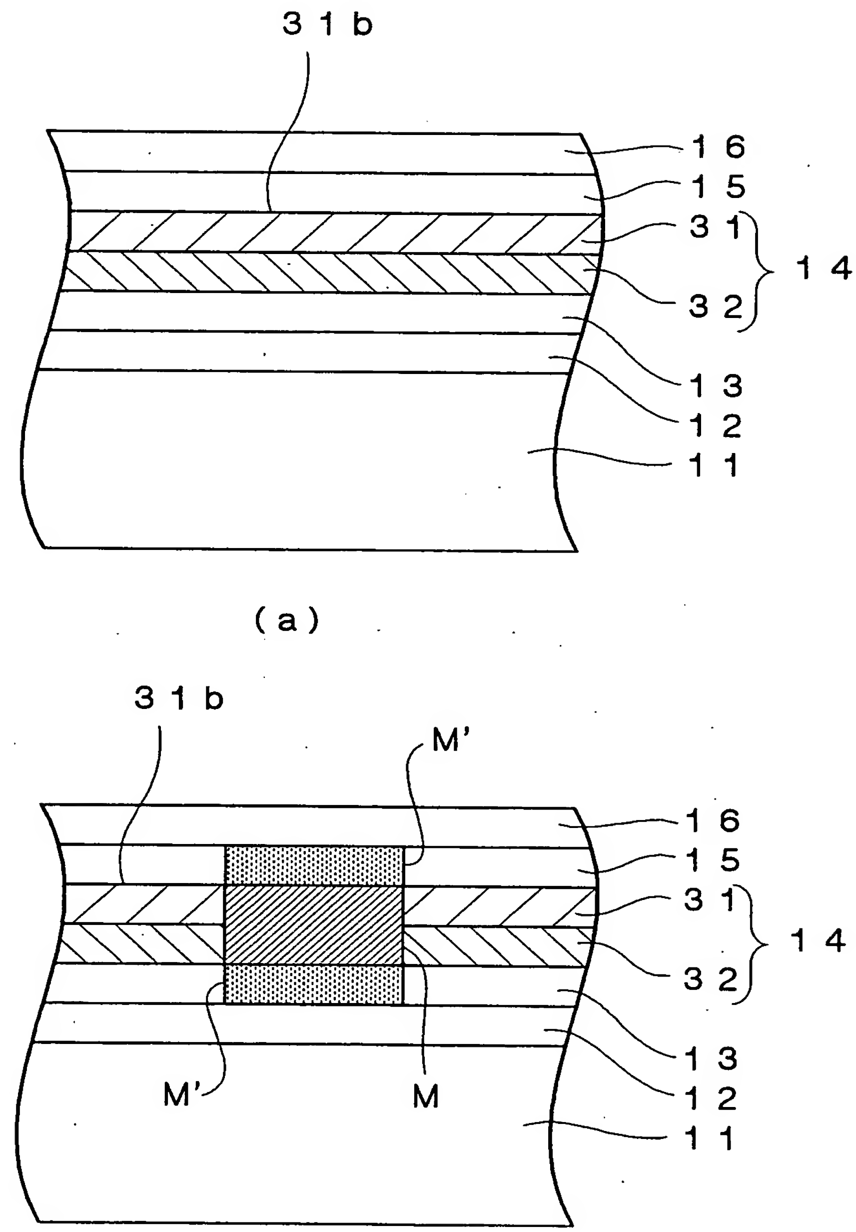


FIG. 2



(a)

(b)

FIG.3

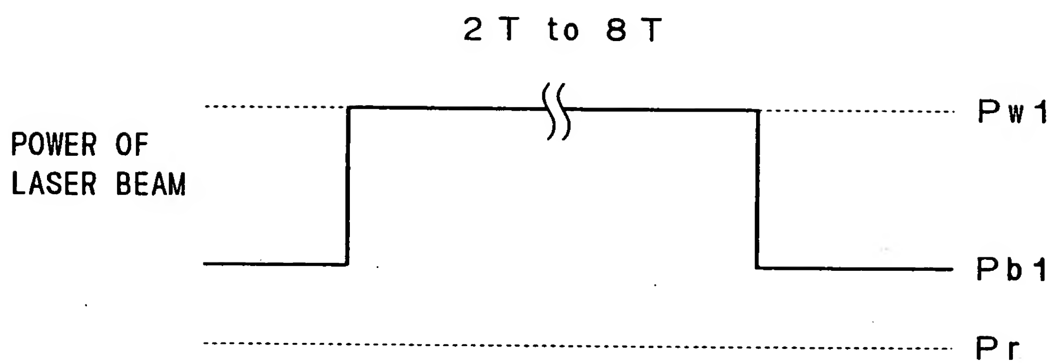


FIG.4(a)

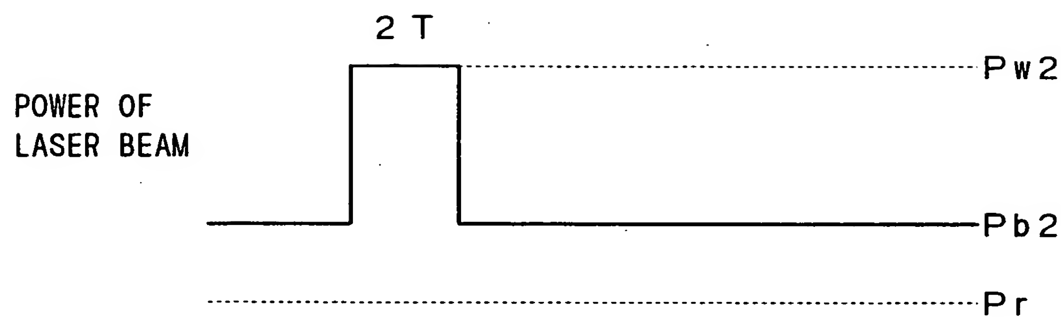

2 T
POWER OF
LASER BEAM
Pw2
Pb2
Pr

FIG.4(b)

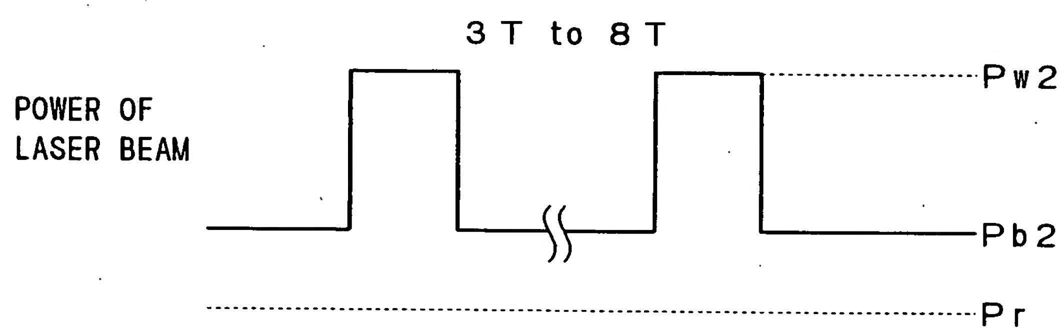
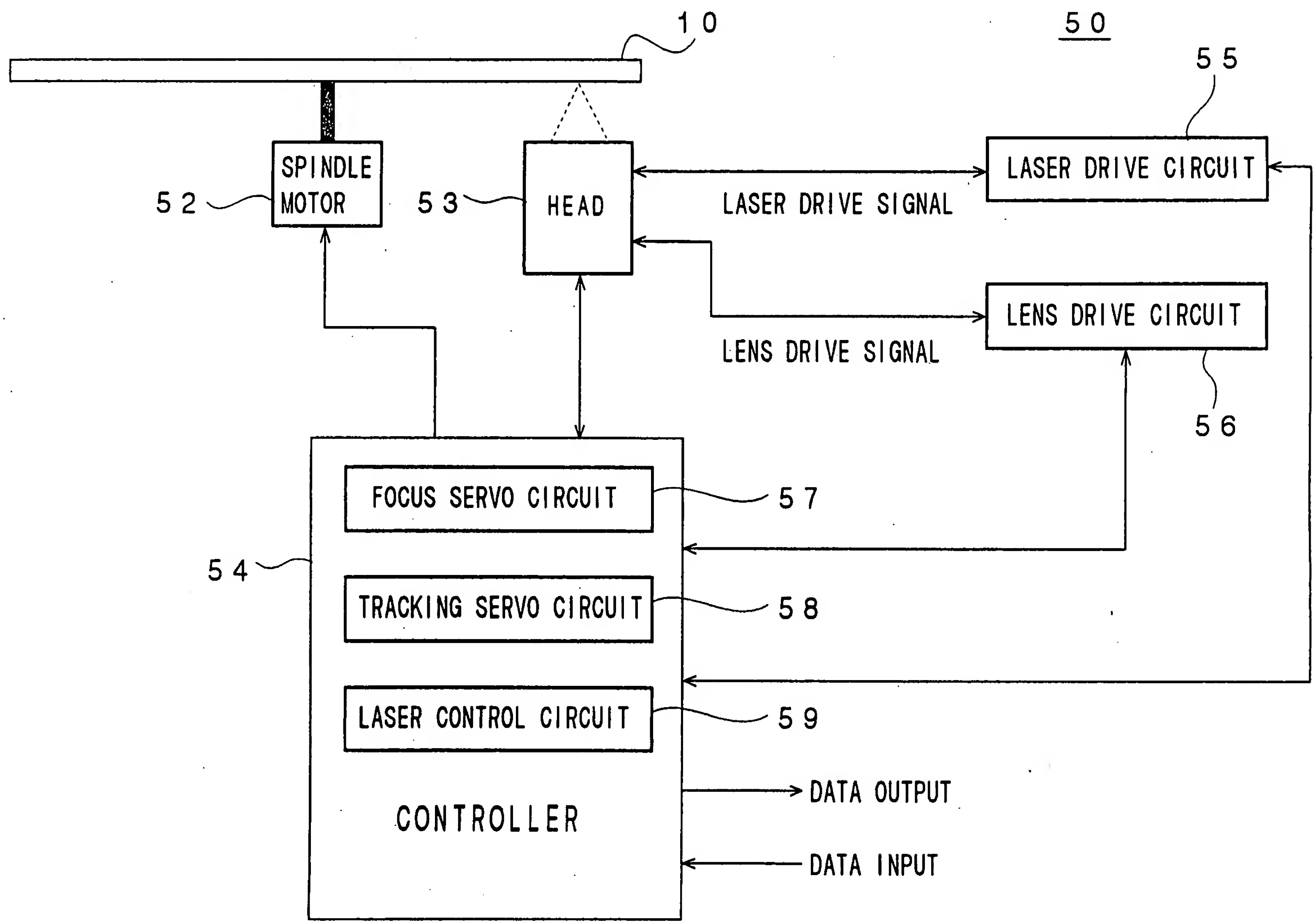

3 T to 8 T
POWER OF
LASER BEAM
Pw2
Pb2
Pr

FIG.5


10
50
55
LASER DRIVE CIRCUIT
SPINDLE MOTOR
52
53
HEAD
LASER DRIVE SIGNAL
LENS DRIVE CIRCUIT
LENS DRIVE SIGNAL
56
FOCUS SERVO CIRCUIT
57
54
TRACKING SERVO CIRCUIT
58
LASER CONTROL CIRCUIT
59
DATA OUTPUT
CONTROLLER
DATA INPUT